NEOSHO BASIN TOTAL MAXIMUM DAILY LOAD

Water Body/Assessment Unit: Neosho River (Chanute)
Water Quality Impairment: Copper

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Upper Neosho

Counties: Coffey, Anderson, Woodson, Allen, and Neosho

HUC 8: 11070204

HUC 11 (HUC 14s)**:** 050 (010, 020, 050)

Drainage Area: 448 square miles (Station 560 drainage only); 4195 sq.mi at USGS Chanute gage

Main Stem Segments: 3, 5, 6, 8, 10 starting near confluence with Crooked Creek in southeastern Coffey County and traveling downstream through Woodson and Allen Counties to northwest Neosho County at monitoring station #560 and confluence with Sutton Creek (**Figure 1**).

Tributary Segments: Sutton Creek (35), Slack Creek (30), Charles Branch Creek (27), Onion Creek (24), Elm Creek (1050), Rock Creek (7), Spring Creek (46), Indian Creek (924), Little Indian Creek (939), Martin Creek (49), Crooked Creek (44)

Designated Uses: Special Aquatic Life Support, Primary Contact Recreation; Domestic Water Supply; Food Procurement; Ground Water Recharge; Industrial Water Supply Use; Irrigation Use; Livestock Watering Use for Main Stem Segments in HUC 11070204.

Impaired Use: Expected Aquatic Life Support

Water Quality Standard: Acute Criterion = WER[EXP[(0.9422*(LN(hardness)))-1.700]]

Hardness-dependent criteria (KAR 28-16-28e(c)(2)(F)(ii)). Aquatic Life (AL) Support formulae are: (where Water Effects Ratio (WER) is 1.0 and hardness is in mg/L).

2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT

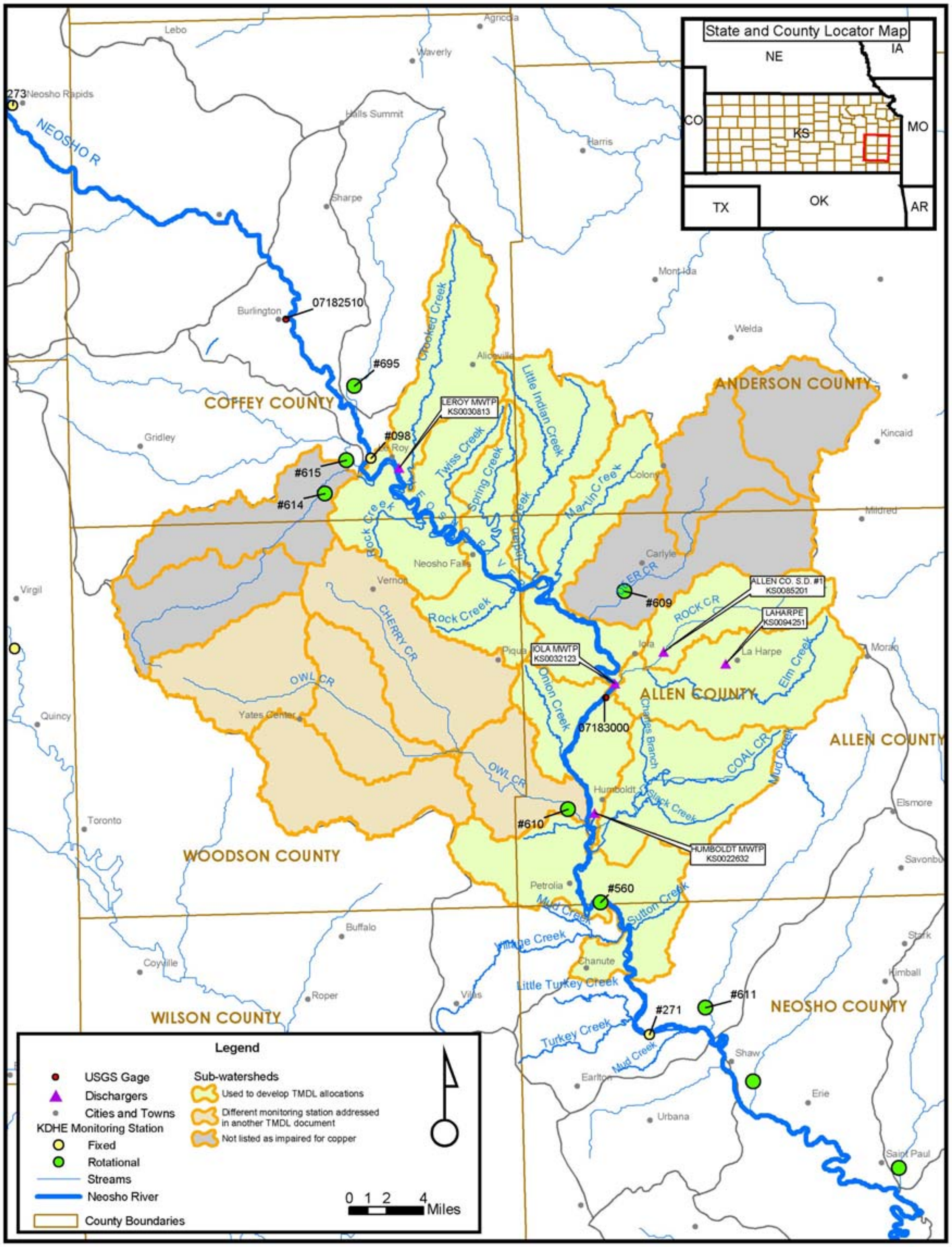
Level of Support for Designated Use under 2002 303(d): Not Supporting Aquatic Life

Monitoring Site: Station 560 near Chanute

Period of Record Used for Monitoring and Modeling: 1985 - 2001 for Station 560. Generalized Watershed Loading Function (GWLF) modeling period for soil data is 1998 –

2002.

Figure 1 Neosho River (Chanute) Location Map



Flow Record: Neosho River near Iola (USGS 07183000). In the absence of specific flow data for Station 560 a watershed ratio approach was used to develop the flow duration curve.

Long Term Flow Conditions: 10% Exceedance Flows = 5700 cfs**,** 95% = 23 cfs

Critical Condition: All seasons; high flows in particular

TMDL Development Tools: Load Duration Curve and Generalized Watershed Loading Function (GWLF) Model

Summary of Current Conditions:

Estimated Current Non-point Loading of Copper from Immediate Watershed:
21.267 lb/day (7762 lb/yr)
(derived from GWLF annual estimate of sediment loading)

Estimated Point Source Load (Total): **0.087 lb/day**
Humboldt MWTP: **0.010 lb/day**
Iola MWTP: **0.058 lb/day**
Allen Co S.D. #1: **0.004 lb/day**
Laharpe: **0.011 lb/day**
Leroy MWTP: **0.004 lb/day**
(assumed copper concentration multiplied by MWTP design flow [0.387 cfs for Humboldt MWTP, 2.151 cfs for Iola, 0.135 cfs for Allen Co. S.D. #1, 0.401 cfs for LaHarpe, and 0.142 cfs for Leroy MWTP])

Estimated Total Current Load: **21.35 lb/day**
(estimated non-point copper load from sediment (GWLF) + estimated point source load)

Summary of TMDL Results (based on flow and load duration):

Average TMDL: **55.136 lb/day**
Waste Load Allocation (WLA): **0.435 lb/day** (all MWTPs)
Average Load Allocation (LA): **49.187 lb/day (5.136 lb/day from Station 560 drainage)**
(Average LA = average TMDL – WLA – average MOS; see **Figure 7** for LA at specific flow exceedance ranges)
Average Margin of Safety (MOS): **5.514 lb/day**

TMDL Source Reduction:

WLA Sources (MWTP): **No reduction necessary**
Non-Point: **No reduction necessary overall**, but within the Station 560 drainage, a potential reduction of **16.131 lb/day (76 percent)** is necessary

GWLF Modeling for Generating Load Estimates: Existing non-point source loads of copper to Neosho River were estimated using the GWLF (Haith, *et al*. 1996) model. The model, in conjunction with some external spreadsheet calculations, estimates dissolved and total copper loads in surface runoff from complex watersheds such as Neosho River. Both surface runoff and groundwater sources are included in the simulations. The GWLF model requires daily precipitation and temperature data, runoff sources and transport, and chemical parameters. Transport parameters include areas, runoff curve numbers (CN)for antecedent moisture condition II, and the erosion product KLSCP (Universal Soil Loss Equation parameters) for each runoff source. Required watershed transport parameters are groundwater recession and seepage coefficients, available water capacity of the unsaturated zone, sediment delivery ratio, monthly values for evapotranspiration cover factors, average daylight hours, growing season indicators, and rainfall erosivity coefficients. Initial values must also be specified for unsaturated and shallow saturated zones, snow cover, and 5-day antecedent rainfall plus snowmelt.

Input data for copper in soil were obtained from Soil Conservation Service (SCS) and USGS (*e.g.* Juracek and Mau 2002 and 2003). For modeling purposes, Neosho River was divided into several subwatersheds. The model was run for each subwatershed separately using a 5-year period, January 1998 - December 2002, and first year results were ignored to eliminate effects of arbitrary initial conditions. Daily precipitation and temperature records for the period were obtained from the Western Regional Climate Center (Haith, *et al*. 1996). All transport and chemical parameters were obtained by general procedures described in the GWLF manual (Haith, *et al*. 1996), and values used in the model are in **Appendix B**. Parameters needed for land use were obtained from the State Soil Geographic (STATSGO) Database compiled by Natural Resources Conservation Service (NRCS) (Schwarz and Alexander 1995).

For each land use area shown on **Figure 4**, NRCS CN, length (L), and gradient of the slope (S) were estimated from intersected electronic geographic information systems (GIS) land use and soil type layers. Soil erodibility factors (K_k) were obtained from the STATSGO database (Schwarz and Alexander 1995). Cover factors (C) were selected from tables provided in the GWLF manual (**Appendix B**). Supporting practice factors of P = 1 were used for all source areas for lack of detailed data. Area-weighted CN and Kk, (LS)k, Ck, and Pk values were calculated for each land use area. Coefficients for daily rainfall erosivity were selected from tables provided in the GWLF manual. Model input variables and model outputs are shown in **Appendix B**.

To calculate the watershed yield for copper, the GWLF model was run to generate the average annual runoff and average annual sediment load generated from each subwatershed. Average sediment copper concentrations were derived from several USGS studies of lake and river bottom sediments in Kansas. The average sediment copper concentrations for this area are approximately 33.5 µg/g (ppm). This mass concentration of copper in sediments was used in conjunction with the total suspended solids (TSS) concentrations from the ambient sampling to determine the particulate portion of the ambient total copper results attributable to copper in suspended sediments. The remainder of the ambient total copper sampling results are, therefore, dissolved copper concentrations.

The ambient dissolved copper concentration was conservatively assumed to be the same concentration as in the runoff generated from the watershed. This fraction was estimated using partitioning assumptions implicit in the model. In addition, the average sediment concentration of 33.5 μg/g soil was used with the GWLF generated average annual sediment yield to calculate the average annual copper yield associated with sediment.

Load Duration Curves: Because loading capacity is believed to vary as a function of the flow present in the stream, **Table 1** was prepared to show the number of water quality samples exceeding the copper acute WQS as a function of flow during different seasons of the year. Ambient water quality data from the KDHE rotational sampling Station 560 were categorized for each of the three defined seasons: spring (Apr-Jul), summer-fall (Aug-Oct) and winter (Nov-Mar). Flow data and ambient water quality data for copper and hardness, collected during 1990, 1994, 1998, and 2002, from station 560 are provided in **Appendix A, Table A-2**. High flows and runoff generally equate to lower flow exceedance (*e.g.*, less than 50 percent) ranges; baseflow and point source influences generally occur in the 75-99 percent flow exceedance range.

From **Table 1**, a total of two acute WQS excursions for total copper were observed (of a total of 23 samples collected) during rotational monitoring, consisting of one during June 1990, and one during April 1994. Both of the exceedances occurred during spring (higher flows), with no exceedances observed during lower flow conditions. These two exceedances account for the impaired water body designation and inclusion on the 2002 Kansas §303(d) list.

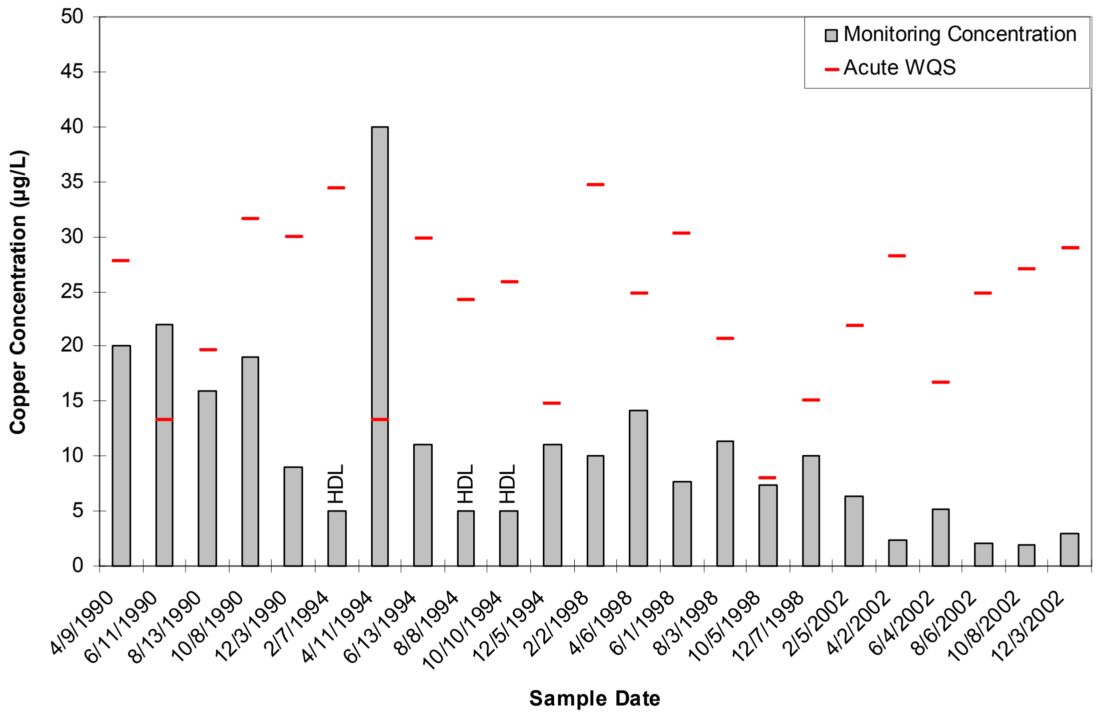
Table 1 Number of Samples Exceeding Copper WQS by Flow during Spring, Summer/Fall, and Winter

Station	Season	Percent Flow Exceedance						Cumulative Frequency
		0 to 10%	10 to 25%	25 to 50%	50 to 75%	75 to 90%	90 to 100%	
Neosho River (Chanute) (560)	Spring	2	0	0	0	0	0	2/8 (25%)
	Summer-Fall	0	0	0	0	0	0	0/8 (0%)
	Winter	0	0	0	0	0	0	0/7 (0%)

Figure 2 compares KDHE measured copper concentrations with paired hardness-specific acute WQS values for total copper. As can be seen in **Figure 2**, a total of two exceedances were measured out of the 23 samples taken, consisting of one during 1990 and one, most recently, during 1994.

Estimated Neosho River (near Chanute) flow data for the associated sample date were used to estimate both the observed load and the acute WQS load (**Figure 3**). Measured copper concentration and the paired hardness-specific data were used to calculate the observed load and the assimilative capacity based on the acute WQS, respectively. Differences in the observed load from the acute WQS load were calculated by subtracting the acute WQS load from the observed load. Positive (*i.e.*, above zero) differences indicated load exceedances.

Figure 2 Comparison of Total Copper Concentrations with Paired Hardness-Specific Acute WQS for Monitoring Station #560

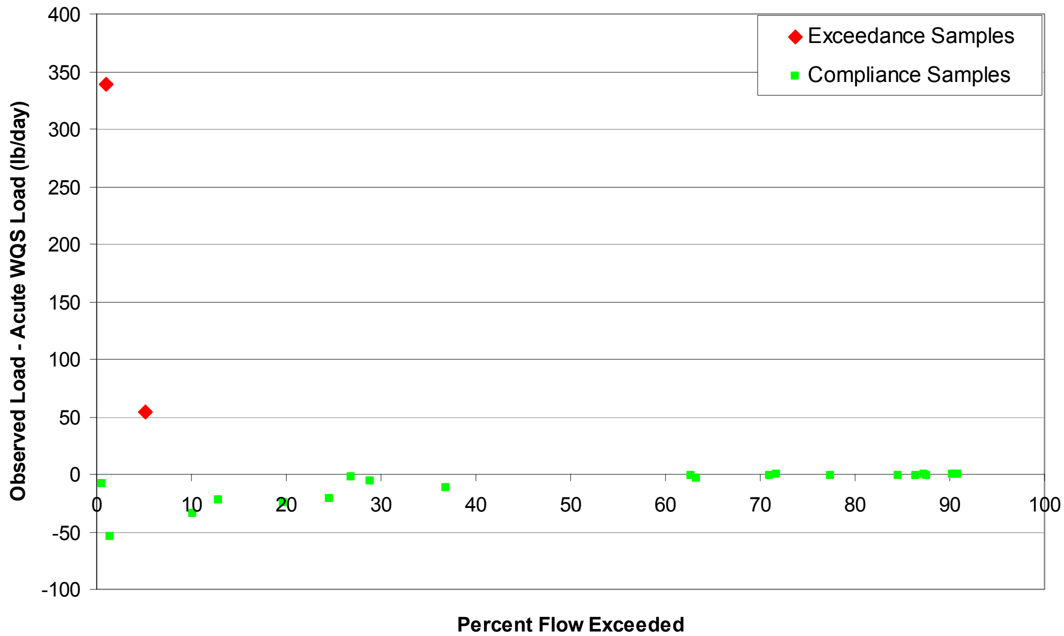


Note: HDL indicates half of detection limit

Compliance with chronic WQS for copper. This document does not address compliance with the chronic copper toxicity because representative data for chronic conditions did not support a 2002 303(d) listing for the Neosho River (Chanute). The listing was based on exceedances of the acute criteria. However, a brief analysis was also conducted to generally evaluate whether compliance with the acute WQS would be adequately protective of chronic toxicity. To perform this evaluation, the average copper concentration (representing the long-term average) was divided by the standard deviation to yield the coefficient of variation (CV). If the CV is greater than 0.3 then the variation in the data is believed to be adequately addressed by the acute WQS, and no further evaluation of chronic toxicity would be necessary. For Neosho River (near Chanute), the CV for the copper concentrations was greater than 0.3 (0.69), suggesting that compliance with the acute WQS would be adequately protective of chronic toxicity as well.

Figure 3 summarizes the copper load exceedances plotted against percent flow exceedances. Only two excursions were observed, which occurred at 1 percent and 5 percent flow exceedance, respectively. This suggests that excursions only occur at higher flows, with no excursions observed in the medium or low flow ranges (*i.e.*, above 10 percent flow exceedance). This observation therefore clearly suggests that copper loading occurs from non-point sources. It was not necessary to demonstrate stable hydrologic conditions because only transient (acute) excursions were considered in this comparison.

Figure 3 Exceedances of Acute Total Copper WQS Load as a Function of Percent Flow



Desired Endpoints of Water Quality (Implied Load Capacity) at Site 560 over 2007 – 2011

The KDHE 2002 303(d) list identifies the aquatic life use of Neosho River (near Chanute) as impaired as a result of acute copper exceedances; accordingly, the Neosho River was targeted for TMDL development. 40 CFR§130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standard." The water quality standards are calculated using the following hardness-dependent equation (KDHE 2003):

acute criterion (WQS) = WER[EXP[(0.9422*(LN(hardness)))-1.700]]

The desired endpoint of the Neosho River (near Chanute) TMDL is for total copper concentrations attributed to identified potential sources of copper in the watershed to remain below the acute WQS in the stream. This desired endpoint should improve water quality in the river at both low and high flows. Seasonal variation is accounted for by this TMDL, since the TMDL endpoint accounts for the low flow conditions usually occurring in the July-November months.

This endpoint will be reached as a result of expected, though unspecified, reductions in sediment loading from the watershed resulting from implementation of corrective actions and best management practices (BMP), as directed by this TMDL Report. Achievement of this endpoint is expected to provide full support of the aquatic life function of the river and attain the acute WQS for copper.

3. SOURCE INVENTORY AND ASSESSMENT

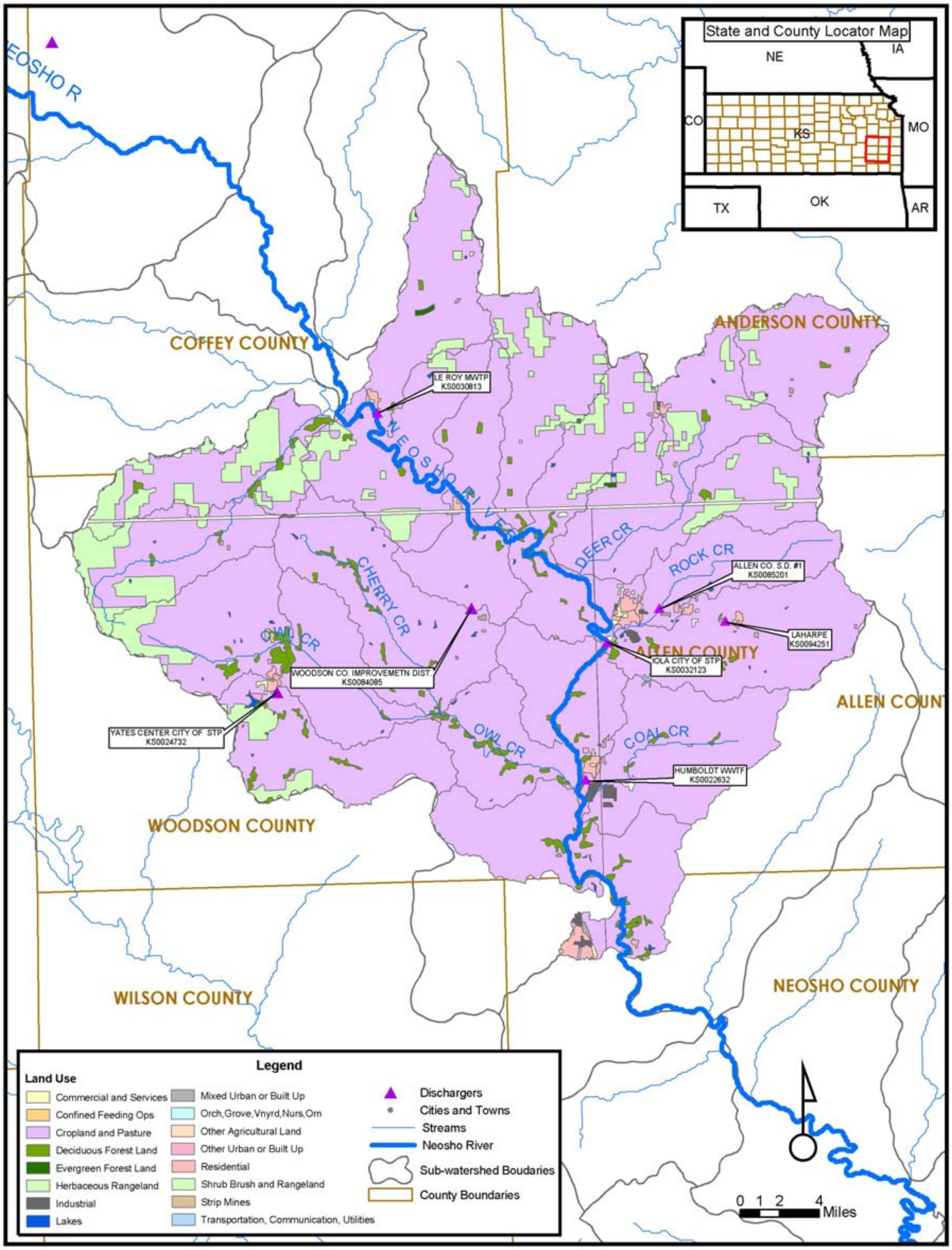
General Watershed Description: The Neosho River (near Chanute) watershed lies within Allen, Neosho, Wilson and Woodson Counties, with the majority lying in Allen County and drains about 4200 square miles. The drainage area associated with Station 560, which is portrayed in light green on **Figure 1,** is approximately 448 square miles. Population statistics for this part of Kansas show generally light to moderate densities. The annual average rainfall in the Neosho River (near Chanute) watershed is 32.4 inches (based on data from Topeka, Kansas). Approximately 70 percent of this precipitation falls between April and September. Ten to 18 inches of snow falls in an average winter. Average temperatures vary from 35 degrees Fahrenheit (°F) in the winter to 78°F in the summer.

Land Use. Table 2 shows the general land use categories within the Neosho River (near Chanute) watershed derived from USEPA BASINS Version 3.0 land use/land cover data (USGS 1994). Cropland and pasture cover approximately 92 percent of the total acreage in the Neosho River (near Chanute) watershed, with herbaceous rangeland covering only 4 percent and all other uses combined covering less than 4 percent. Most of the riparian corridor traverses through cropland and pasture and there is an insignificant amount (less than 2 percent of the total) of commercial or developed land in the watershed. **Figure 4** depicts the general land use categories that occur within the Neosho River (near Chanute) watershed. Given the small to moderate size of the rural population and the limited residential and commercial land use, land development impacts to water quality in Neosho River (near Chanute) are expected to be limited.

Table 2 Land Use Categories

LAND USE	Total Acres	% of Total
COMMERCIAL AND SERVICES	621	0.22
CROPLAND AND PASTURE	263,782	91.98
FOREST LAND	5,240	1.9
HERBACEOUS RANGELAND	11,290	3.93
INDUSTRIAL	1,329	0.46
LAKES	152	0.05
MXD URBAN OR BUILT-UP	216	0.08
OTHER AGRICULTURAL LAND	54	0.02
OTHER URBAN OR BUILT-UP	216	0.08
RESERVOIRS	213	0.07
RESIDENTIAL	3,239	1.13
STRIP MINES	153	0.05
TRANS, COMM, UTIL	144	0.05
TRANSITIONAL AREAS	48	0.02
TOTALS	**286,784**	**100.00**

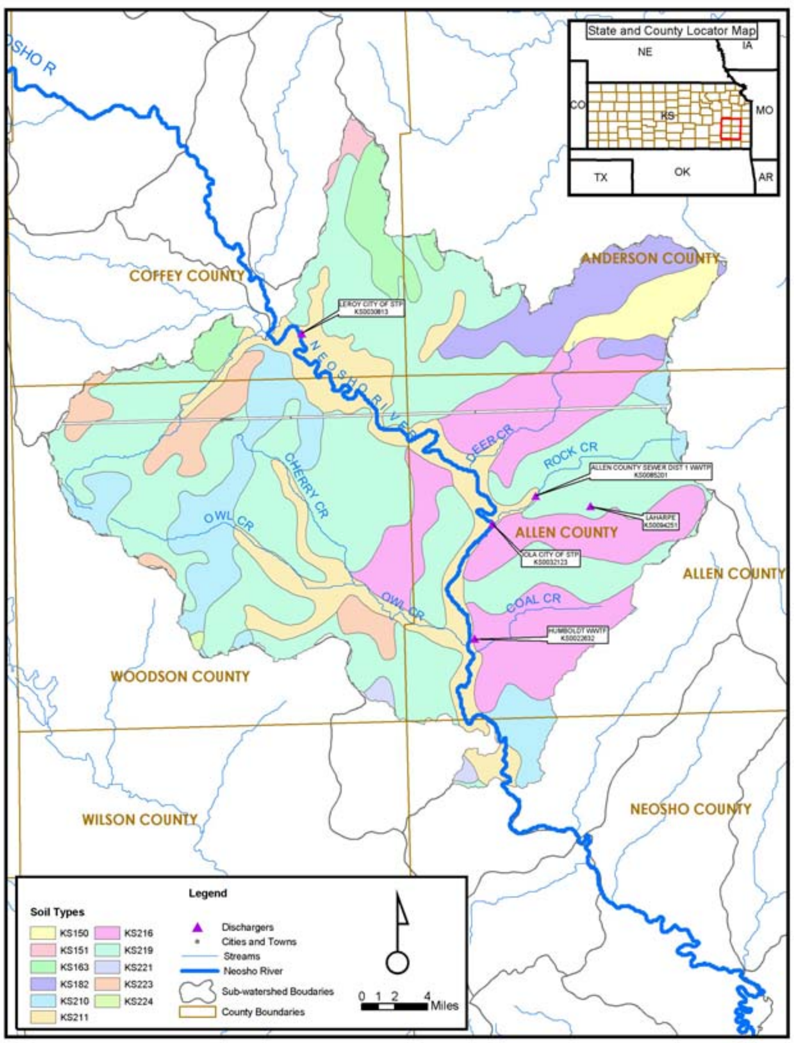
Figure 4 Neosho River (near Chanute) Watershed Land Use Map



Soil. **Figure 5**, derived from STATSGO data, generally represents soil types prevalent throughout the Neosho River (near Chanute) watershed. Major soil types throughout the region of the Neosho River (near Chanute) watershed are silty clay loam and loam (Schwarz and Alexander 1995).

No data for copper in soil or sediment were found specifically within the Neosho River (near Chanute) watershed, but copper soil and sediment data were collected from Pottawatomie County (Whittemore and Switek 1977). In that study, copper concentrations were measured in rocks (two limestone and two shale), soil, and stream sediments. The total and acid soluble fraction of copper concentrations found in rocks ranged from 16-34 parts per million (ppm) and 1.6-9.5 ppm, respectively. The total, exchangeable fraction, and acid soluble fraction of copper found in soil ranged from 18-56 ppm, 2.4-3.1 ppm, and 5.0-6.8 ppm, respectively. The total, exchangeable fraction and acid soluble fraction of copper found in stream sediments from five locations in Pottawatomie County ranged from 15-28 ppm, 0.4-2 ppm, and 5.1-8.7 ppm, respectively.

Figure 5 Neosho River (near Chanute) Watershed Soil Map



Point Source Discharges

Six NPDES-permitted municipal wastewater dischargers are located within the Neosho River (near Chanute) watershed; however, one of these is currently non-discharging. **Table 3** lists the five permitted dischargers within the watershed.

Table 3 NPDES Permitted Dischargers to Neosho River (near Chanute)

NPDES Discharger	Individual Design Flow (cfs)
Humboldt MWTP	0.387
Iola MWTP	2.151
Allen Co. S.D. #1	0.135
Laharpe	0.401
Leroy MWTP	0.142
TOTAL	3.215

At monitoring Station 560, excursions from the copper WQS appear to occur primarily under runoff conditions or higher flows. Of significance to point source dischargers is the lack of excursions under low flow in all seasons, especially during winter. Therefore, point sources are not seen as a significant source of copper loading in the watershed.

Effluent monitoring requirements for each of the above dischargers indicates that no permit limits have been set for copper, and thus no monitoring data were available from any of these MWTPs.

Non-point Sources

Non-point sources include those sources that cannot be identified as entering the water body at a specific location. Non-point sources for copper may originate from roads and highways, urban areas, and agriculture lands. Some automobile brakepads are a source of copper as are some building products such as plumbing, wiring, and paints (Boulanger and Nikolaidis 2003).

In a University of Connecticut study, Boulanger and Nikolaidis (2003) found elevated concentrations of total copper in runoff from copper roofed areas (ranging from 1,460 micrograms per liter (µg/L) to 3,630 µg/L). They also found moderately high concentrations of total copper in runoff from paved and lawn areas (about 16 µg/L and 20 µg/L, respectively). Automobile brake pad dust containing copper particles, automobile fluid leakage, and fertilizer and pesticide applications were reportedly responsible for the concentrations of copper on the paved and lawn areas. In a similar study conducted at the University of Maryland, Davis et al. (2001) found the largest contribution of copper from brake emissions (47 percent), building siding (22 percent), and atmospheric deposition (21 percent), with smaller contributions from copper roofing, tires and oil leakage (10 percent). Although these studies suggest that residential, roadway, and commercial land uses may represent non-point pollutant sources of copper, given the small proportion of these types of land use that occur in the Neosho River (near Chanute) watershed, such copper contributions are assumed to be minimal.

Agricultural sources. The most probable non-point source of copper may be from the extensive amount of agriculture activities that occur in the watershed. Eighteen livestock operations are registered within the watershed, but none are of sufficient size to warrant an NPDES permit. Two of these facilities are swine operations and the other 16 are cattle (dairy or beef) operations. Permitted livestock facilities have waste management systems designed to minimize runoff entering the operation or detaining runoff originating from the area. Such systems are designed to retain the 25-year, 24-hour rainfall/runoff event, as well as an anticipated 2 weeks of normal wastewater from the operations. Rainfall events typically coincide with stream flows which are exceeded less than 1-5 percent of the time. Requirements for maintaining the water level of the waste lagoons a certain distance below the lagoon berms ensures retention of the runoff from these intense, local storm events. Copper sulfate is widely used for treatment and nutrition of livestock, treatment of orchard diseases, and removal of nuisance aquatic vegetation such as fungi and algae. However, no specific data are available on copper concentrations for any of these facilities.

Following is a brief discussion of agricultural land use activities in Allen County. Although portions of the Neosho River (near Chanute) watershed lie outside of Allen County, county census data are expected to be relatively accurate and provide a qualitative indication of the agricultural land uses activities in the watershed that may be primary pathways for copper loading to the receiving waters. There are approximately 30,000 combined livestock and poultry in Allen County (KASS 2002; SETA 1997). Dairy and beef cattle may suffer from various hoof diseases that are typically treated with a copper sulfate hoof bath (Davis 2004 and Ames 1996). Improper disposal of the copper sulfate bath water onto the land could subsequently infiltrate to groundwater and represents a possible non-point source of copper in the watershed.

According to the Office of Social and Economic Trend Analysis (SETA) (1997), there were approximately 6,600 hogs on 59 farms in Allen County in 1997. It is common practice to feed copper supplements to hogs and to a lesser extent other livestock (Richert 1995). A hog grown to 250 pounds will have released approximately 1.5 tons of copper-containing waste (Richert 1995). Thus, past improper management of this waste may have created a legacy source of copper in the Neosho River (near Chanute) watershed.

Soybean crops cover approximately 62,000 acres in Allen County, with approximately 36,000 acres dedicated to corn, sorghum, and wheat combined (SETA 1997). Copper deficiency in soybeans, for example, is corrected by application of 3 to 6 pounds of copper as copper sulfate per acre (Mengel 1990). In addition, copper-based pesticides are currently the 18th most widely used pesticide in the United States (Avery 2001). Such agricultural applications could therefore represent a non-point source of copper within the Neosho River (near Chanute) watershed.

Non-point Source Assessment Conclusion

The above discussion concerning non-point sources of copper is a qualitative assessment of the potential anthropogenic sources of copper in the Neosho River (near Chanute) watershed. It is possible that some copper may originate from automobile brake deposits, building materials, and copper-based pesticides and feed or fertilizers. However, due to the relatively low density of human population in the Neosho River (near Chanute) watershed, copper loadings from urban land uses may be quite limited, while those from agricultural land use activities described above may be more substantial.

Naturally occurring copper in soil may constitute a substantial portion of estimated loadings to Neosho River (near Chanute). To calculate the watershed yield for copper, the GWLF model was run to generate the average annual runoff and average annual sediment load discharged to Neosho River (near Chanute). This modeling was conducted based on average sediment copper concentrations derived from several U.S. Geological Survey (USGS) studies of lake and river bottom sediments in Kansas (Juracek and Mau 2002, 2003). The average sediment copper concentration for this area is approximately 33.5 micrograms per gram (µg/g) (ppm), which is elevated compared to soil in many other parts of the country.

4. ALLOCATION OF POLLUTION REDUCTION RESPONSIBILITY

Following is a discussion of the results of the TMDL process for total copper at Neosho River (near Chanute), and an evaluation of potential sources and responsibility.

TMDL Calculations

Figure 6 is a plot of hardness versus flow to delineate any potential correlation between these variables in the Neosho River (near Chanute) watershed. Hardness is known to generally be inversely proportional to flow. This assertion is supported by **Figure 6**, which demonstrates an apparently statistically significant relationship between these two variables at Neosho River (near Chanute) of ($p<0.05$).

This evaluation is important because it helps define the effects of flow on copper bioavailability and toxicity and, in addition provides valuable insight into hydrologic flow conditions for the Neosho River (near Chanute) watershed. Because the regression was found to be statistically significant ($p < 0.05$), the regression equation (y = 89.246x0.1865) was used to define hardness at any particular flow exceedance range. This allowed for derivation of "interim" WQS values for copper within individual flow exceedance ranges and used to estimate TMDL loads within each of these ranges. The average of these TMDL estimates across all flow ranges was used as the TMDL for the watershed.

Figure 6 Correlation Between Hardness and Flow at Neosho River (near Chanute)

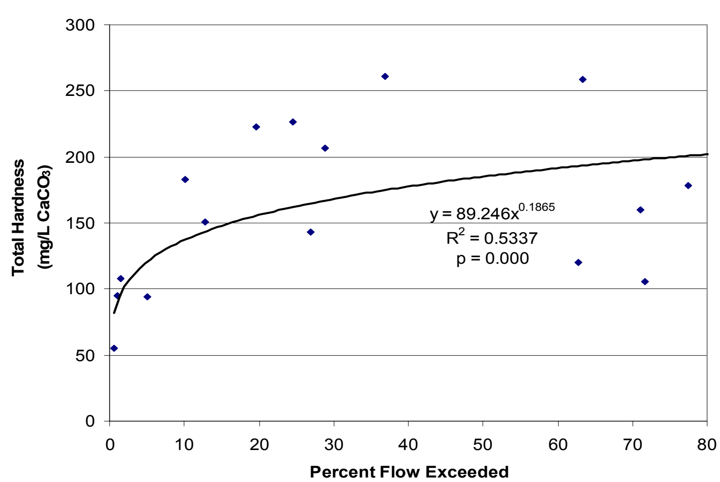


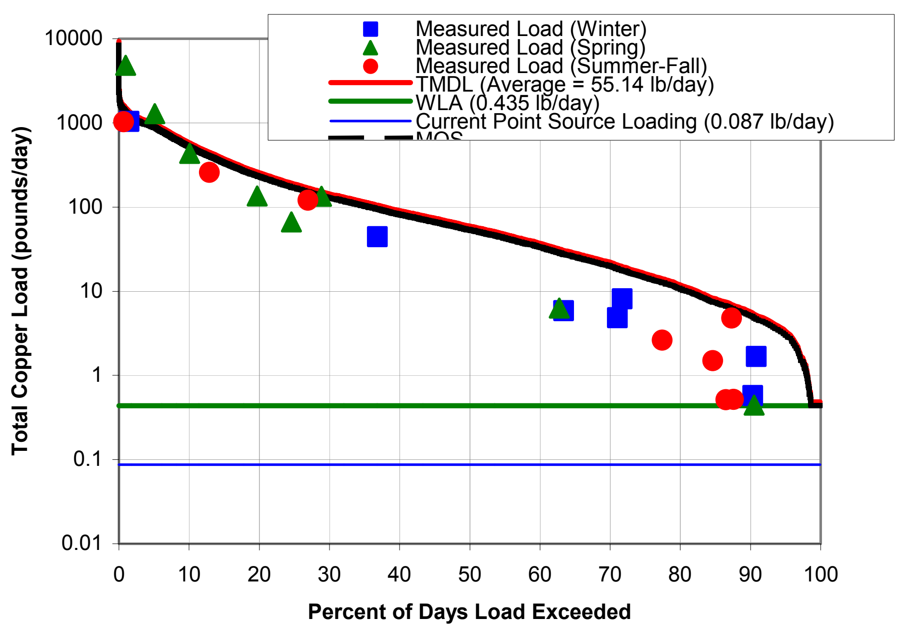
Figure 7 shows the load duration curve for copper which also defines the Neosho River (near Chanute) TMDL, WLA, LA, and MOS. These values, along with other key loading and allocation estimates, are shown in the Information Sheet at the beginning of this document. **Figure 7** also depicts measured loadings of copper from the KDHE water quality monitoring station in relation to the acute TMDL. The TMDL was developed using the acute WQS derived from the flow-hardness regression equation.

The area below the TMDL with MOS and above the WLA represents the LA in **Figure 7**. The diagram also shows the LA range based on flow exceedance. Current point source loading is shown on **Figure 7** as a line below the WLA estimate, indicating that no point source load reduction would be necessary. The current non-point loading estimate is not shown in **Figure 7** because the GWLF estimate is based on average loadings rather than flow exceedance ranges. Therefore, the current non-point loading estimate was only compared to the average TMDL value. Based on these calculations, the calculated average TMDL for total copper in Neosho River (near Chanute) is 55.136 lbs/day (10 tons/yr). Current point source loading may be overestimated in **Figure 7** because measured loads at the 80 to 100 percent flow exceedance range were less than the estimated current point source loading.

The calculated average TMDL for total copper in Neosho River (near Chanute) was computed:

Average TMDL (55.136 lb/day) = LA (49.187 lb/day) + WLA (0.435 lb/day) + average MOS (5.514 lb/day)

Figure 7 Load Duration Curve Used to Derive TMDL

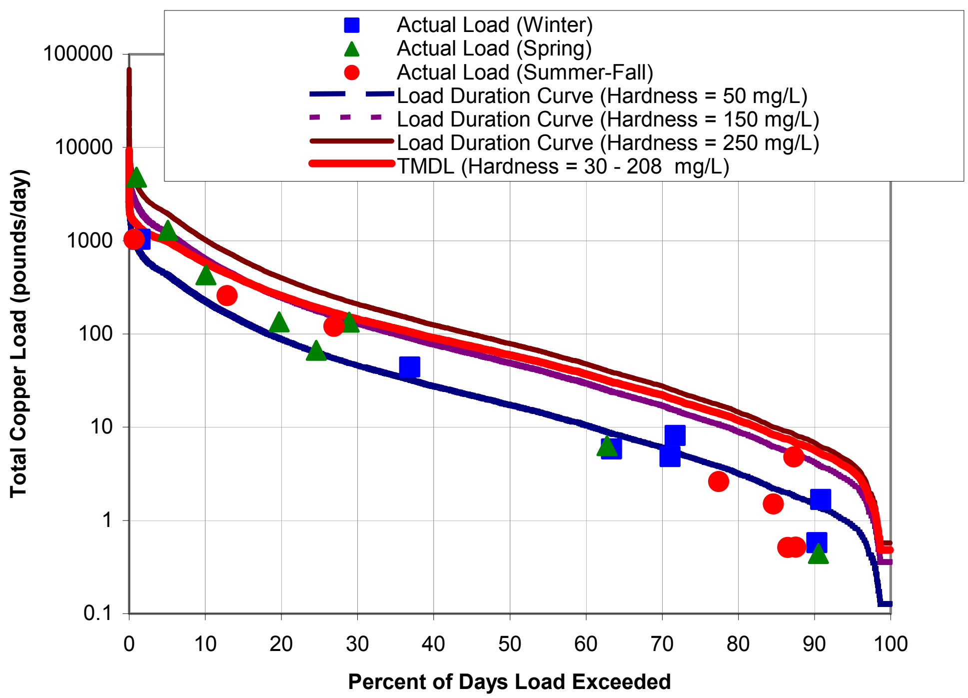


Results of regression analysis and normality testing. Water hardness data were not subjected to normality testing due to the positive correlation between flow and hardness as indicated by the regression equation (**Figure 6**). For the data sets used to support all averaged load estimates such as

TMDL, LA/WLA, MOS, and load reduction, results of normality testing indicated that these data were not normally distributed, and log transformation of the data was necessary before the calculations could be completed.

Figure 8, which shows more potential WQS exceedances for total copper, compares the measured total copper loading to the load duration curve for three specific hardness values that are representative of typical seasonal variation in Neosho River (near Chanute). **Figure 8** appears to be an effective predictor of potential WQS exceedances in part because three representative hardness ranges are used to estimate total copper loadings to the watershed. In an evaluation of possible seasonal effects of copper loading in Neosho River (near Chanute), it is apparent from **Table 1** that the exceedances would generally occur during spring when flows were highest.

Figure 8 Comparison of Measured total Copper Load by Season to Load Duration Curve at Specific Hardness Values



TMDL Pollutant Allocation and Reductions

Any allocation of wasteloads and loads will be made in terms of total copper reductions. Yet, because copper loadings are a manifestation of multiple factors, the initial pollutant load reduction responsibility will be to decrease the total copper inputs over the critical range of flows encountered on the Neosho River (near Chanute) system. Allocations relate to the average copper levels seen in the Neosho River system within the Station 560 incremental drainage for the critical higher flow conditions. Additional monitoring over time will be needed to further ascertain the relationship between copper reductions of non-point sources, flow conditions, and concentrations within the stream and upstream inputs.

In calculating the TMDL the mean of all TMDL values across different flow ranges was used. TMDL at each percent flow exceedance range was calculated by multiplying the associated flow and copper WQS at the particular flow exceedance range. This is represented graphically by the integrated area under the copper LDC (**Figures 7 and 8**). The area is segregated into allocated areas assigned to point sources (WLA) and non-point sources (LA). Future increases in wasteloads should be offset by reductions in the loads contributed by non-point sources. This offset, along with appropriate limitations, is expected to eventually eliminate the impairment.

WLA for Neosho River (near Chanute)

Since the lowest flows of the Neosho River were adjusted to the design flow, the total WLA for the TMDL is equal to the minimum TMDL with MOS, *i.e.*, 90 percent of the acute and chronic TMDL load at the design flow, respectively. **Table 4** shows the specific WLAs for each of the five dischargers. **Figure 7** clearly shows that based on the estimated WLA, there appear to be no historical excursions for copper from point sources.

Table 4 Calculated WLA for Each of the Five NPDES Permitted Dischargers

NPDES Discharger	Design Flow (cfs)	Current estimated loading (lb/day)	Individual WLA (lb/day)
Humboldt MWTP	0.387	0.010	0.052
Iola MWTP	2.151	0.058	0.291
Allen Co. S.D. #1	0.135	0.004	0.018
Laharpe	0.401	0.011	0.054
Leroy MWTP	0.142	0.004	0.019
TOTAL	**3.215**	**0.087**	**0.435**

LA for Neosho River (near Chanute)

The LA was estimated by filling in the formula:

Average LA (49.187 lb/day) = TMDL (55.136 lb/day) – MOS (5.514 lb/day) – WLA (0.435 lb/day)

This LA calculation strongly suggests that the majority of copper loading emanates from non-point sources, and that the contribution from NPDES point source discharges is, by comparison, negligible. The load from all non-point sources is contributed from miscellaneous land uses, although the majority of the LA appears to come from soil loading, which includes contributions of natural background sources of copper.

The LA assigns responsibility for maintaining the historical average in-stream copper levels at Station 560 to below acute hardness-dependent WQS values for specific flow exceedance levels. As seen on **Figure 7**, the assimilative capacity for LA equals zero for flows at 3.215 cfs (92.5-100 percent exceedance), since the flow at this condition may be entirely effluent created, and then increases to the TMDL curve with increasing flow beyond 3.215 cfs.

Point Source Load Reduction

A point source discharger is responsible for maintaining its system in proper working condition and an appropriate capacity to handle anticipated wasteloads of its populations. The State and NPDES permits will continue to be issued at 5-year intervals, with inspection and monitoring requirements and conditional limits on the quality of effluent released from these facilities. Ongoing inspections and monitoring of the systems will be made to ensure that minimal contributions have been made by this source.

Based on the preceding assessment, the five permitted point source discharges to the watershed are a minor source of copper loading to the Neosho River upstream of Station 560. The design flow of the discharging point source equals the lowest flows seen at Station 560 (92.5-100 percent flow exceedance), and the WLA equals the TMDL curve across this flow exceedance range (**Figure 7**). No reduction in point source loading is considered necessary under this TMDL.

Non-Point Source Load Reduction

Based on the prior assessment of sources, the distribution of excursions from water quality standards at Station 560 and the relationship of those excursions to runoff conditions and seasons, non-point sources are clearly regarded as the primary contributing factor to the occasional total copper excursions in the watershed.

The LA equals zero for flows at 3.215 cfs (92.5 – 99.9 percent exceedances, as seen on **Figures 7**), since the flow at this condition may be entirely created by the effluent, and then increases to the TMDL curve with increasing flow beyond 3.215 cfs (**Figure 7**). Sediment control practices such as buffer strips and grassed waterways should help reduce any anthropogenic non-point copper loadings under higher flows as well as reduce the sediment transported to the stream that may occur during the critical flow period.

The anticipated average non-point source reduction was calculated for the incremental drainage monitored by Station 560 and modeled by GWLF. The estimated incremental non-point load reduction of 16.131 lbs/day represents an approximate 76 percent reduction from current non-point loading estimates coming from the immediate watershed above Station 560. Because of the overriding influence of incoming flow and loads above the Station 560 watershed, the average load allocation does not require a load reduction since the GWLF estimated load is less than the desired load allocation measured in the Neosho River below Chanute. Thus, load reductions will be a localized activity to reduce incremental and episodic loadings that might cause exceedance of the acute copper criterion.

Margin of Safety

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take the MOS into consideration. The MOS is a conservative measure incorporated into the TMDL equation that accounts for the uncertainty associated with calculating the allowable copper pollutant loading to ensure water quality standards are attained. USEPA guidance allows for use of implicit or explicit expressions of the MOS, or both. When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a specific percentage of the TMDL is set aside to account for uncertainty, then the MOS is considered explicit. This copper TMDL relies on both an implicit and explicit MOS derived from a variety of calculations and assumptions made which are summarized below. The net effect of the TMDL with MOS is that the assimilative capacity of the watershed is slightly reduced. This TMDL incorporates an explicit MOS by using a curve representing 90 percent of the TMDL as the average MOS.

NPDES permitting procedures used by KDHE are conservative and provide an implicit MOS built into the calculations (*e.g.*, whether or not to allow a mixing zone). As an example, the calculation to determine the permit limit is based on the long term average treatment efficiency based on a 90 percent probability that the discharge will meet the WLA. It is common knowledge that the efficiency of a mechanical MWTP is greater during prolonged dry weather than under wet weather conditions. The log-normal probability distribution curves for treatment plant performance used by USEPA to determine the long-term average takes into account wet weather reduction in efficiency for calculating the 90th percentile discharge concentration of copper (USEPA 1996). During wet weather periods there would be water flowing in Neosho River (near Chanute), further diluting the MWTP discharge. Another conservative assumption that is the WLA calculation uses the design flow rather than actual effluent flows, which are lower.

Uncertainty Discussion

Key assumptions used. Following is a list of operating assumptions utilized to support the calculations, due in part to the limited data set.

- The lowest stream flow was adjusted to assure that it would not drop below the design flow of the five MWTPs
- Concentration of copper in wastewater effluent occurred at one-half the analytical detection limit, 5 µg/L, is the assumed value.
- Matched flow data for USGS station for Iola was used rather than actual flow data for Neosho River (near Chanute).
- Water hardness values used for flow-hardness regression equation to calculate WQS for copper.
- Output from GWLF model for non-point source loading was compared to output from incremental LDCs to estimate non-point load reduction.
- Total loading data was not normal and required log-transformation to support the calculations.

The LDC method is used to calculate TMDLs in general because it relies on measured water quality data and paired water hardness data, and a wide range of "flow exceedance" data representing a complete range of flows anticipated at Neosho River (near Chanute). Given the lack of water quality data, GWLF is the most reliable method for deriving current incremental non-point source loading and non-point load reductions because of the large non-point source data base throughout the watershed.

Using measured WQS excursions (Figure 3) to estimate load reduction. Load reduction is defined as the positive difference between the WQS and the measured load (exceedance), and may be estimated from the load exceedances shown on **Figure 3**. However, due to the small number of exceedances from the overall water quality monitoring data, the uncertainty was large and therefore the non-point source reduction value is only an estimate.

Comparing GWLF output with LDC TMDL. It is possible to compare the non-point loads for copper using the GWLF and LDC methods. The three basic differences between the GWLF and LDC approaches to making these estimates are: (1) GWLF output is based on watershed precipitation data rather than measured flow data and therefore results would not be expected to be comparable between the two methods; (2) the GWLF algorithms more completely account for copper loadings (including natural background concentrations of copper in soil) because GWLF estimates the total amount of sediment loading from the watershed to the receiving water; and (3) the ambient water quality data used to develop the LDC only accounts for the portion of copper detected in the water column and does not take into account the copper loading from the watershed that resides in the bed load. Furthermore, the LDC can only estimate the incremental loading caused by localized runoff below the Iola gaging station. When the flow coming into Station 560 from above Chanute is accounted, the allowable loading is greater than the GWLF output. The incremental 11 percent increase in flow between Iola and Station 560 allows for a relatively small amount of loading to meet the TMDL (5.136 lbs/day). Thus, the higher copper loading estimates provided by the GWLF output can really only be compared to the estimated incremental loading that occurs in the vicinity of Chanute..

Seasonal Variability: Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs take into consideration seasonal variability in applicable standards. WQS exceedances occurred during spring and high flow seasons only, demonstrating that high flows and seasonal variation are controlling factors in this watershed.

State Water Plan Implementation Priority: Because the copper impairment is due to natural contributions, this TMDL will be a Low Priority for implementation.

Unified Watershed Assessment Priority Ranking: This watershed lies within the Upper Neosho Basin (HUC 8: 11070204) with a priority ranking of 20 (High Priority for restoration).

Priority HUC 11s and Stream Segments: Because the natural background affects the entire watershed, no priority subwatersheds or stream segments will be identified.

5. IMPLEMENTATION

Copper containing chemicals are used extensively in agriculture. Copper sulfate is probably the most common chemical used in the area. Copper sulfate is used as a feeding supplement or dip for hogs, cattle, and other farm animal. It is also is used to clear ponds and irrigation canals of algae.

Desired Implementation Activities

1. Identify sources of copper in stormwater runoff.
2. Install grass buffer strips where needed along streams.
3. Educate users of copper-containing chemicals concerning possible pollution problems

Implementation Programs Guidance

Non-Point Source Pollution Technical Assistance – KDHE

- Support Section 319 demonstration projects for pollution reduction from livestock operations in watershed.
- Provide technical assistance on practices geared to small livestock operations which minimize impact to stream resources.
- Investigate federal programs such as the Environmental Quality Improvement Program, which are dedicated to priority subbasins through the Unified Watershed Assessment, to priority stream segments identified by this TMDL.

Water Resource Cost Share & Non-Point Source Pollution Control Programs – SCC

- Install livestock waste management systems for manure storage.
- Implement manure management plans.
- Coordinate with USDA/NRCS Environmental Quality Improvement Program in providing educational, technical and financial assistance to agricultural producers.

Riparian Protection Program – SCC

- Develop riparian restoration projects along targeted stream segments, especially those areas with baseflow.
- Design winter feeding areas away from streams.

Buffer Initiative Program – SCC

- Install grass buffer strips near streams.
- Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

Extension Outreach and Technical Assistance - Kansas State University

- Educate livestock producers on riparian and waste management techniques.
- Educate chemical and herbicide users on proper application rates and timing.
- Provide technical assistance on livestock waste management design.
- Continue Section 319 demonstration projects on livestock management.

Agricultural Outreach – KDA

- Provide information on livestock management to commodity advocacy groups.
- Support Kansas State outreach efforts.

Timeframe for Implementation: Continued monitoring over the years from 2002 to 2007.

Targeted Participants: Primary participants for implementation will be the landowners immediately adjacent to Neosho River (Chanute) that use copper-containing chemicals. Some inventory of copper uses should be conducted in 2005-2006 to identify such activities. Such an inventory would be done by local program managers with appropriate assistance by commodity representatives and state program staff in order to direct state assistance programs to the principal activities influencing the quality of the streams in the watershed during the implementation period of this TMDL.

Milestone for 2007: The year 2007 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from the Neosho River (Chanute) watershed should indicate no evidence of increasing copper levels relative to the conditions seen in 1993-2001. Should the case of impairment remain, source assessment, allocation and implementation activities will ensue.

Delivery Agents: The primary delivery agents for program participation will be the Kansas Department of Health and Environment and the State Conservation Commission.

Reasonable Assurances:

Authorities: The following authorities may be used to direct activities in the watershed to reduce pollution.

1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.

2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.

4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.

5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan.*

6. The *Kansas Water Plan* and the Neosho Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan Fund, annually generates $16-18 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a Low Priority consideration.

Effectiveness: Buffer strips are touted as a means to filter sediment before it reaches a stream and riparian restoration projects have been acclaimed as a significant means of stream bank stabilization. The key to effectiveness is participation within a finite subwatershed to direct resources to the activities influencing water quality. The milestones established under this TMDL are intended to gauge the level of participation in those programs implementing this TMDL.

With respect to copper, should participation significantly lag below expectations over the next five years or monitoring indicates lack of progress in improving water quality conditions, the state may employ more stringent conditions on agricultural producers and urban runoff in the watershed in order to meet the desired copper endpoint expressed in this TMDL. The state has the authority to impose conditions on activities with a significant potential to pollute the waters of the state under K.S.A. 65-171. If overall water quality conditions in the watershed deteriorate, a Critical Water Quality Management Area may be proposed for the watershed.

6. MONITORING

KDHE will continue to collect bimonthly samples at rotational Station 560 in 2004 and 2008, including total copper samples in order to assess progress and success in implementing this TMDL. Should impaired status remain, the desired endpoints under this TMDL may be refined and more intensive sampling may need to be conducted under higher flow conditions over the period 2007-2011. Use of the real time flow data available at the Neosho River USGS stream gaging station near Iola, or another appropriate station, can help direct these sampling efforts. Also, use of USEPA Method 1669 - Sampling Ambient Water for Trace Metals at USEPA Water Quality Criteria Levels for ultra-clean copper sampling and analysis could help to further define potentially bioavailable and toxic forms of copper occurring in the subwatershed.

7. FEEDBACK

Public Meetings: Public meetings to discuss TMDLs in the Neosho Basin were held January 9, 2002 in Burlington, March 4, 2002 in Council Grove, and July 30, 2004 in Marion. An active Internet Web site was established at http://www.kdhe.state.ks.us/tmdl/ to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Neosho Basin.

Public Hearing: Public Hearings on the TMDLs of the Neosho Basin were held in Burlington and Parsons on June 3, 2002.

Basin Advisory Committee: The Neosho Basin Advisory Committee met to discuss the TMDLs in the basin on October 2, 2001, January 9, March 4, and June 3, 2002.

Discussion with Interest Groups: Meetings to discuss TMDLs with interest groups include:
Kansas Farm Bureau: February 26 in Parsons and February 27 in Council Grove

Milestone Evaluation: In 2007, evaluation will be made as to the degree of implementation that has occurred within the watershed and current condition of the Neosho River (Chanute) watershed. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

Consideration for 303(d) Delisting: The wetland will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process: Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2003 that will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2003-2007.

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APPENDIX A
WATER QUALITY DATA

Table A-1: Data Used to Generate the Neosho River (near Chanute) Flow Duration Curve

P	Flow (cfs)	
	07183000	Neosho River (Chanute) (560)
0.1	39100	43706.2
0.2	31800	35546.2
0.3	28600	31969.2
0.4	26400	29510.1
0.5	24600	27498.0
0.6	23500	26268.4
0.7	22400	25038.8
0.8	21700	24256.4
0.9	20600	23026.8
1	19800	22132.5
2	14700	16431.7
3	12400	13860.8
4	11000	12295.9
5	9830	10988.0
6	8530	9534.9
7	7480	8361.2
8	6510	7276.9
9	5760	6438.6
10	5090	5689.6
11	4540	5074.8
12	4090	4571.8
13	3720	4158.2
14	3370	3767.0
15	3050	3409.3
16	2780	3107.5
17	2550	2850.4
18	2320	2593.3
19	2150	2403.3
20	1990	2224.4
21	1850	2067.9
22	1720	1922.6
23	1600	1788.5
24	1500	1676.7
25	1400	1564.9
26	1320	1475.5
27	1240	1386.1
28	1170	1307.8
29	1100	1229.6
30	1040	1162.5
31	993	1110.0
32	944	1055.2
33	898	1003.8
34	850	950.1
35	809	904.3
36	769	859.6
37	730	816.0

38	691	772.4
39	653	729.9
40	625	698.6
41	597	667.3
42	573	640.5
43	544	608.1
44	519	580.1
45	498	556.7
46	475	531.0
47	451	504.1
48	434	485.1
49	410	458.3
50	394	440.4
51	377	421.4
52	359	401.3
53	342	382.3
54	326	364.4
55	309	345.4
56	293	327.5
57	277	309.6
58	264	295.1
59	254	283.9
60	238	266.0
61	224	250.4
62	212	237.0
63	199	222.4
64	189	211.3
65	179	200.1
66	170	190.0
67	161	180.0
68	153	171.0
69	145	162.1
70	138	154.3
71	128	143.1
72	120	134.1
73	112	125.2
74	106	118.5
75	100	111.8
76	94	105.1
77	89	99.5
78	84	93.9
79	79	88.3
80	72	80.5
81	68	76.0
82	63	70.4
83	58	64.8
84	53	59.2
85	49	54.8
86	46	51.4
87	43	48.1

88	40	44.7
89	37	41.4
90	34	38.0
91	30	33.5
92	28	31.3
93	25	28.2
94	23	26.2
95	20	23.2
96	17	20.2
97	11	14.2
98	6.9	10.1
99	1.6	4.8

Table A-2: Water Quality Data for Station 560 and Matched Flow Data Used to Support the Load Duration Curve

Collection Date	Flow (cfs)	Copper Concentration (µg/L)	Hardness (mg/L $CaCO_3$)	Acute WQS (µg/L)
4/9/1990	1100	20	207	27.78
6/11/1990	9730	22	94	13.21
8/13/1990	1250	16	143	19.61
10/8/1990	42	19	237	31.56
12/3/1990	31	9	224	29.93
2/7/1994	195	10*	259	34.32
4/11/1994	20000	40	95	13.34
6/13/1994	2040	11	223.00	29.8
8/8/1994	87	10*	178.601	24.18
10/10/1994	50	10*	191.449	25.81
12/5/1994	123	11	105.756	14.76
2/2/1998	736	10	261.305	34.6
4/6/1998	5060	14.2	182.772	24.71
6/1/1998	1440	7.7	226.778	30.28
8/3/1998	3770	11.4	151.098	20.65
10/5/1998	23200	7.4	55.139	7.99
12/7/1998	17100	10.1	108.03	15.06
2/5/2002	128	6.3	160.096	21.81
4/2/2002	32	2.3	210.53	28.23
6/4/2002	202	5.2	120.19	16.65
8/6/2002	41	2.1	183.09	24.75
10/8/2002	45	1.9	201.03	27.03
12/3/2002	33	2.9	215.98	28.92

Note: * indicates not detected at the method detection limit shown

APPENDIX B
INPUT AND OUTPUT DATA FOR GWLF MODEL

Neosho River (near Chanute) Input

LAND USE	AREA(ha)	CURVE NO	KLSCP
CROPLAND AND PASTURE	106765.	88.0	0.02000
DECIDUOUS FOREST LAND	2078.	80.0	0.02000
HERBACEOUS RANGELAND	4648.	87.0	0.02000
OTHER AGRICULTURAL LAND	22.	87.0	0.02000
STRIP MINES	62.	98.0	0.02000
LAKES	61.	0.0	0.00000
RESERVOIRS	86.	0.0	0.00000
COMMERCIAL AND SERVICES	251.	98.0	0.02000
INDUSTRIAL	538.	98.0	0.02000
MXD URBAN OR BUILT-UP	1567.	98.0	0.02000

MONTH	ET CV()	DAY HRS	GROW. SEASON	EROS. COEF
JAN	9.000	9.7	0	.2
FEB	9.000	10.6	0	.2
MAR	9.000	11.8	0	.2
APR	9.000	13	0	.2
MAY	9.000	14	1	.3
JUNE	9.000	14.5	1	.3
JULY	9.000	14.3	1	.3
AUG	9.000	13.4	1	.3
SEPT	9.000	12.2	1	.3
OCT	9.000	11	1	.3
NOV	9.000	10	0	.2
DEC	9.000	9.4	0	.2

ANTECEDENT RAIN+MELT FOR DAY -1 TO DAY -5

0 0 0 0 0

INITIAL UNSATURATED STORAGE (cm) = 10

INITIAL SATURATED STORAGE (cm) = 0

RECESSION COEFFICIENT (1/day) = .01

SEEPAGE COEFFICIENT (1/day) = 0

INITIAL SNOW (cm water) = 0

SEDIMENT DELIVERY RATIO = 0.065

UNSAT AVAIL WATER CAPACITY (cm) = 10

Neosho River (near Chanute) Output

Neosho Chanute YEAR SIMULATION

YEAR	PRECIP	EVAPOTRANS	GR.WAT.FLOW	RUNOFF	STREAMFLOW
			(cm)		
1	88.2	83.0	0.0	15.2	15.2
2	69.6	59.3	0.0	9.3	9.3
3	108.5	80.5	0.0	28.9	28.9
4	70.8	61.5	0.0	9.3	9.3
5	74.8	56.8	0.0	17.9	17.9

YEAR	EROSION	SEDIMENT
	(1000 Mg)	
1	849.0	55.2
2	770.9	50.1
3	1379.2	89.6
4	721.9	46.9
5	956.3	62.2